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(54) **SYSTEM AND METHOD FOR CHARACTERIZING BURST INFORMATION**

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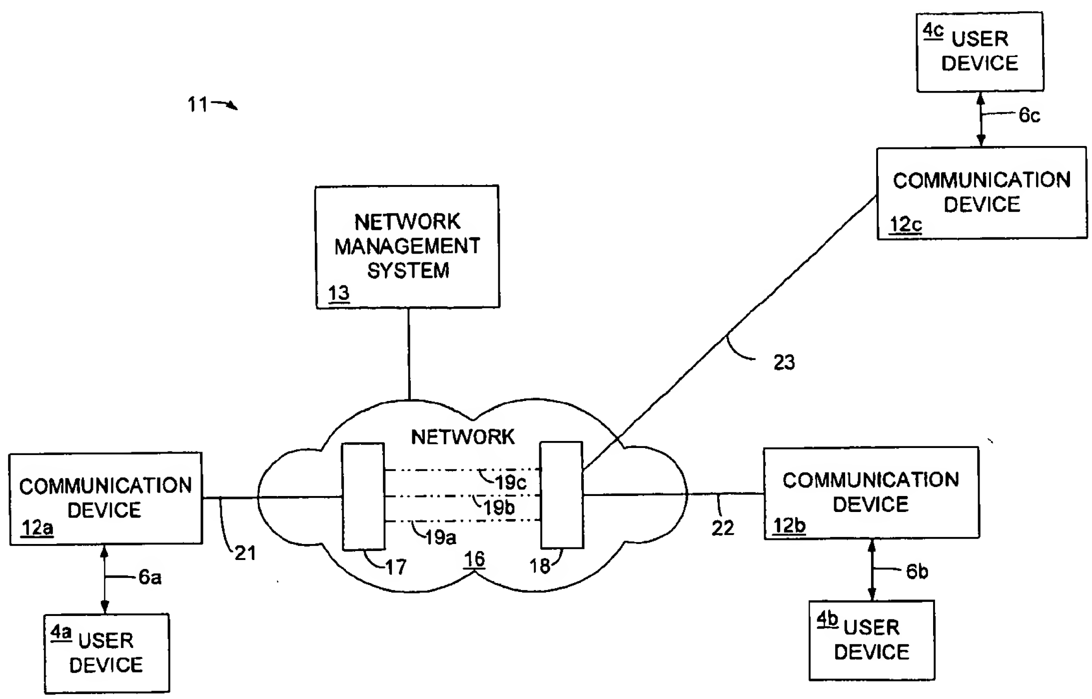
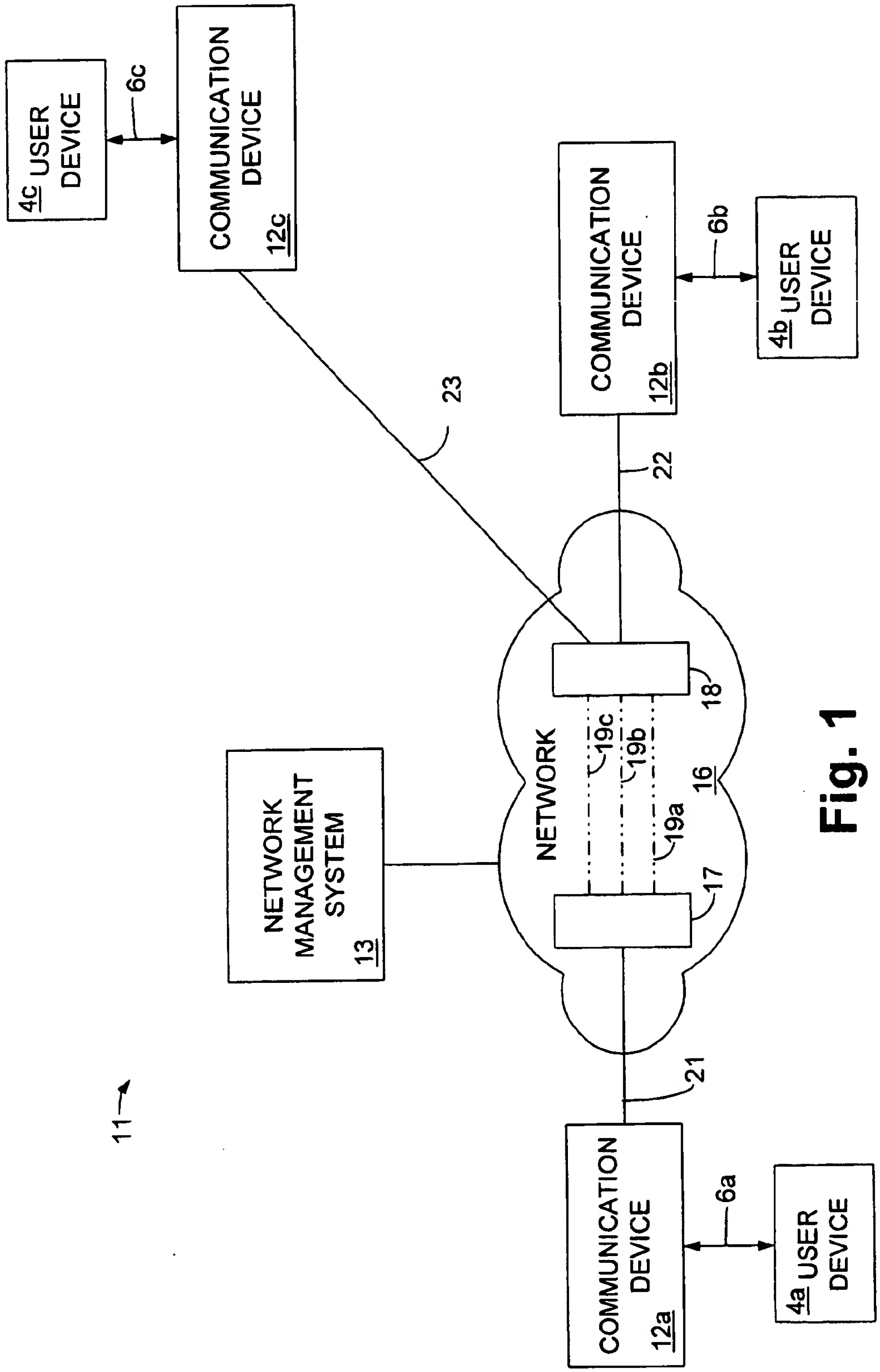
(57) **ABSTRACT**

A system and method for characterizing burst data in a communication network detects the occurrence of burst information and categorizes the burst information into at least one category based upon either bits or frames. Because one second time intervals may contain multiple categories of burst information, the analysis of which may overwhelm a network management system, the burst categorization logic of the present invention allows the capture and analysis of multiple burst categories in a single time interval over a long period of time, thereby allowing the analysis of a large amount of information without overwhelming a network management system with data.





4c USER DEVICE
6c
COMMUNICATION DEVICE 12c
COMMUNICATION DEVICE 12b
6b
4b USER DEVICE
23
22
NETWORK MANAGEMENT SYSTEM 13
NETWORK
18
19c
19b
19a
16
17
21
11
COMMUNICATION DEVICE 12a
6a
4a USER DEVICE

Fig. 1

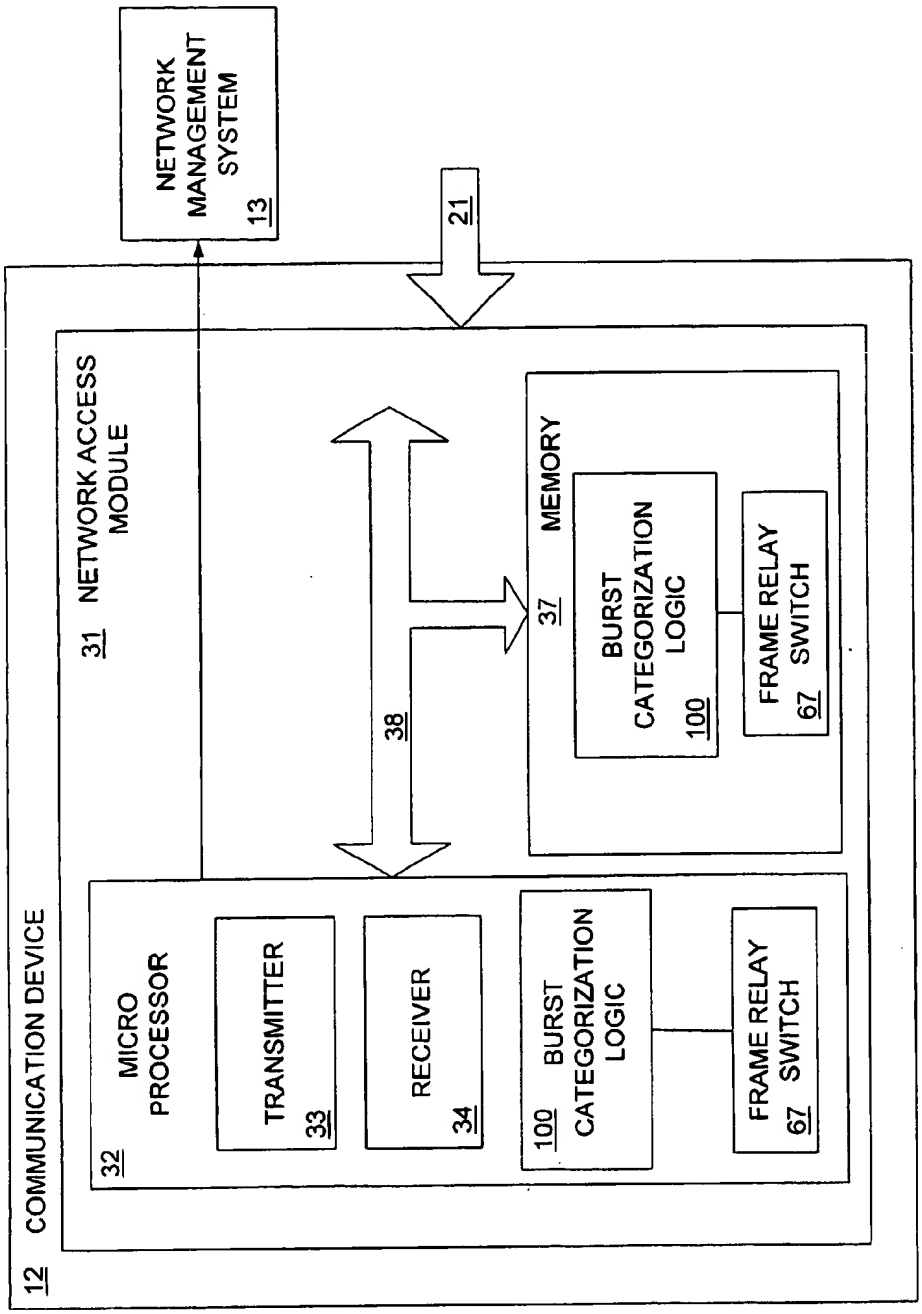

NETWORK MANAGEMENT SYSTEM
13
21
COMMUNICATION DEVICE
12
NETWORK ACCESS MODULE
31
MEMORY
37
BURST CATEGORIZATION LOGIC
100
FRAME RELAY SWITCH
67
38
MICRO PROCESSOR
32
TRANSMITTER
33
RECEIVER
34
BURST CATEGORIZATION LOGIC
100
FRAME RELAY SWITCH
67

Fig. 2

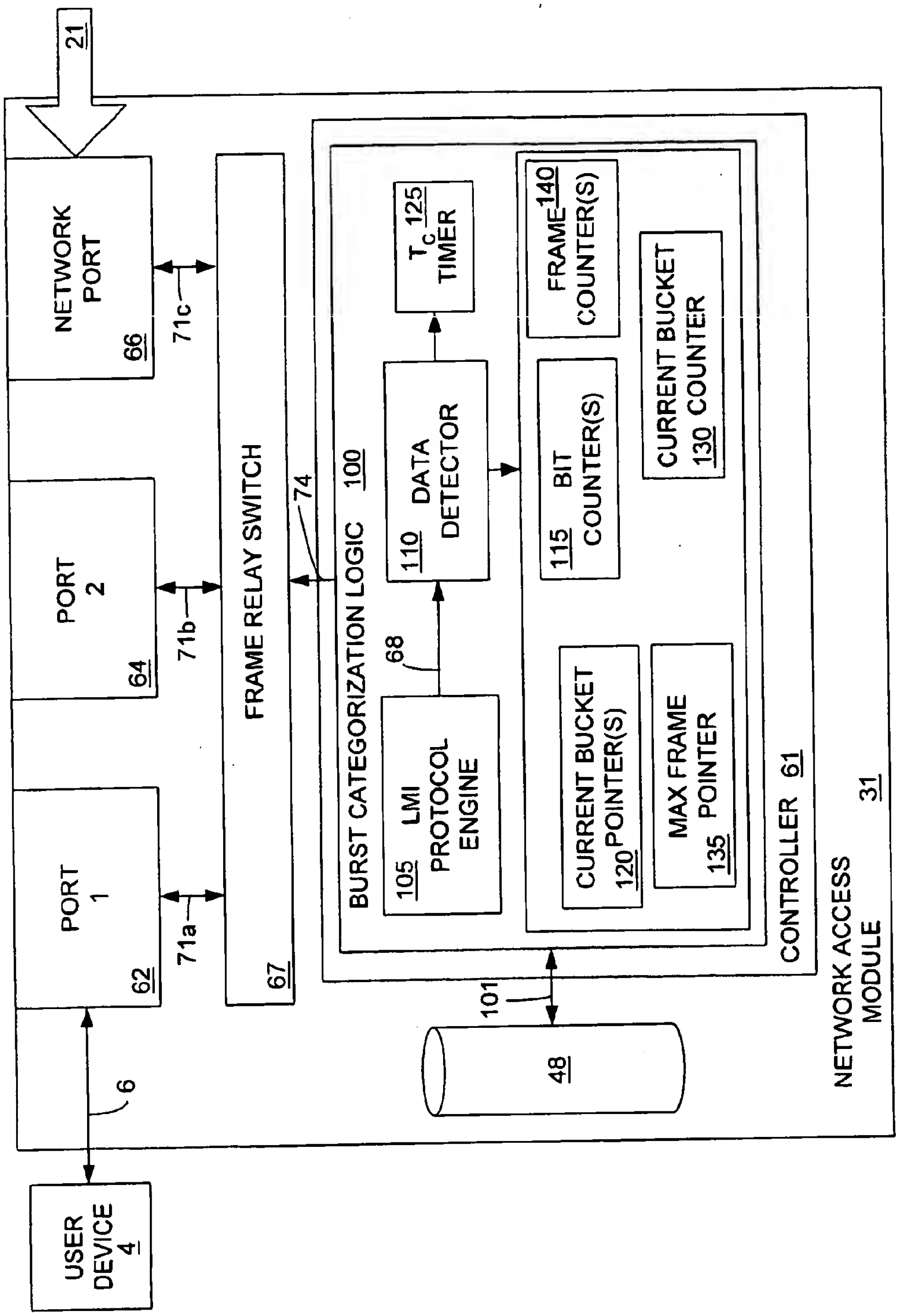

21
NETWORK PORT 66
71c
PORT 2 64
71b
PORT 1 62
71a
6
USER DEVICE 4
FRAME RELAY SWITCH 67
74
BURST CATEGORIZATION LOGIC 100
105 LMI PROTOCOL ENGINE
68
110 DATA DETECTOR
T_c 125 TIMER
115 BIT COUNTER(S)
FRAME 140 COUNTER(S)
CURRENT BUCKET 130 COUNTER
CURRENT BUCKET 120 POINTER(S)
MAX FRAME 135 POINTER
CONTROLLER 61
101
48
NETWORK ACCESS MODULE 31

Fig. 3

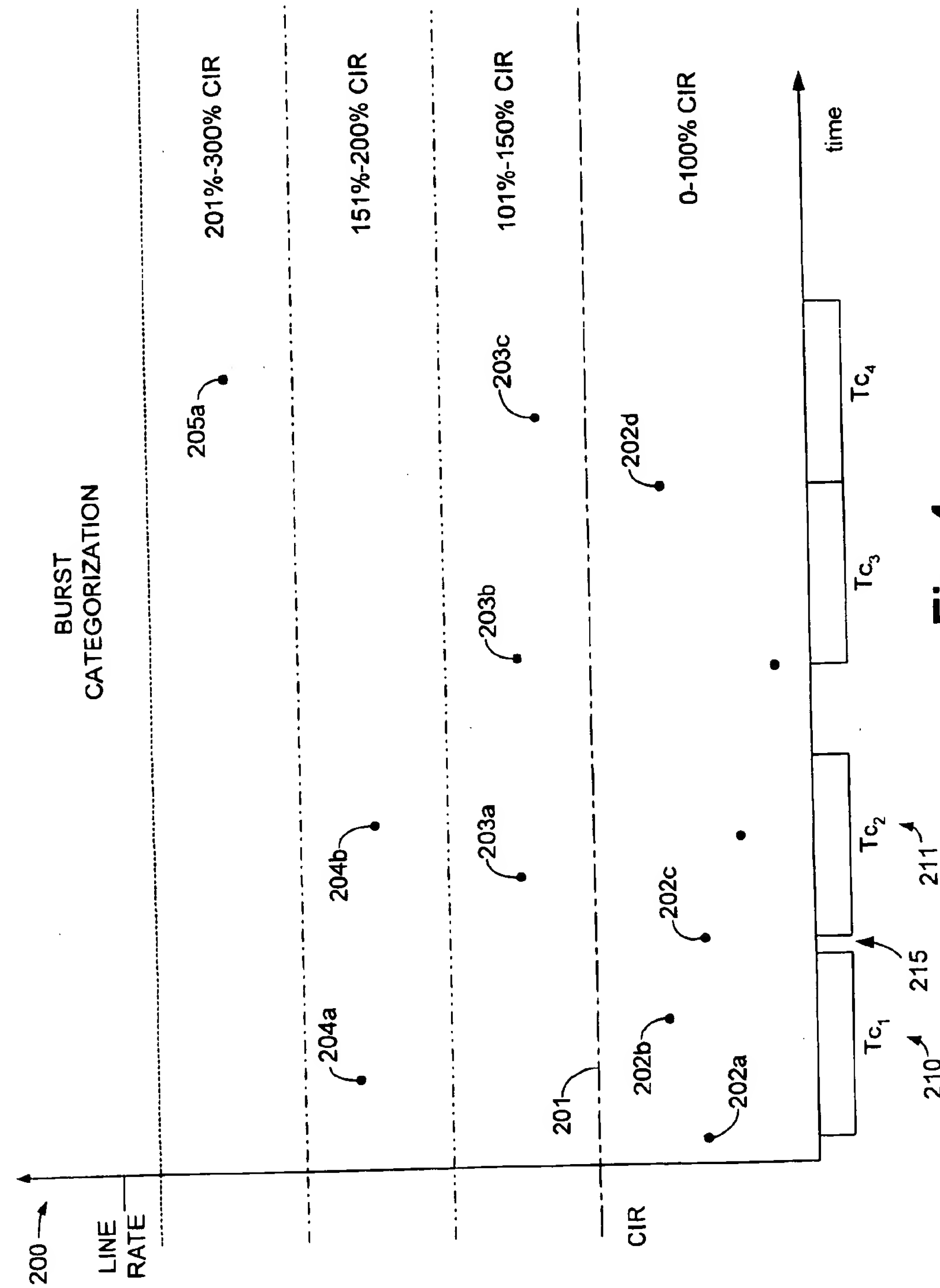

BURST
CATEGORIZATION
201%-300% CIR
151%-200% CIR
101%-150% CIR
0-100% CIR
time
LINE
RATE
CIR
200
201
202a
202b
202c
202d
203a
203b
203c
204a
204b
205a
Tc1
Tc2
Tc3
Tc4
210
211
215

Fig. 4

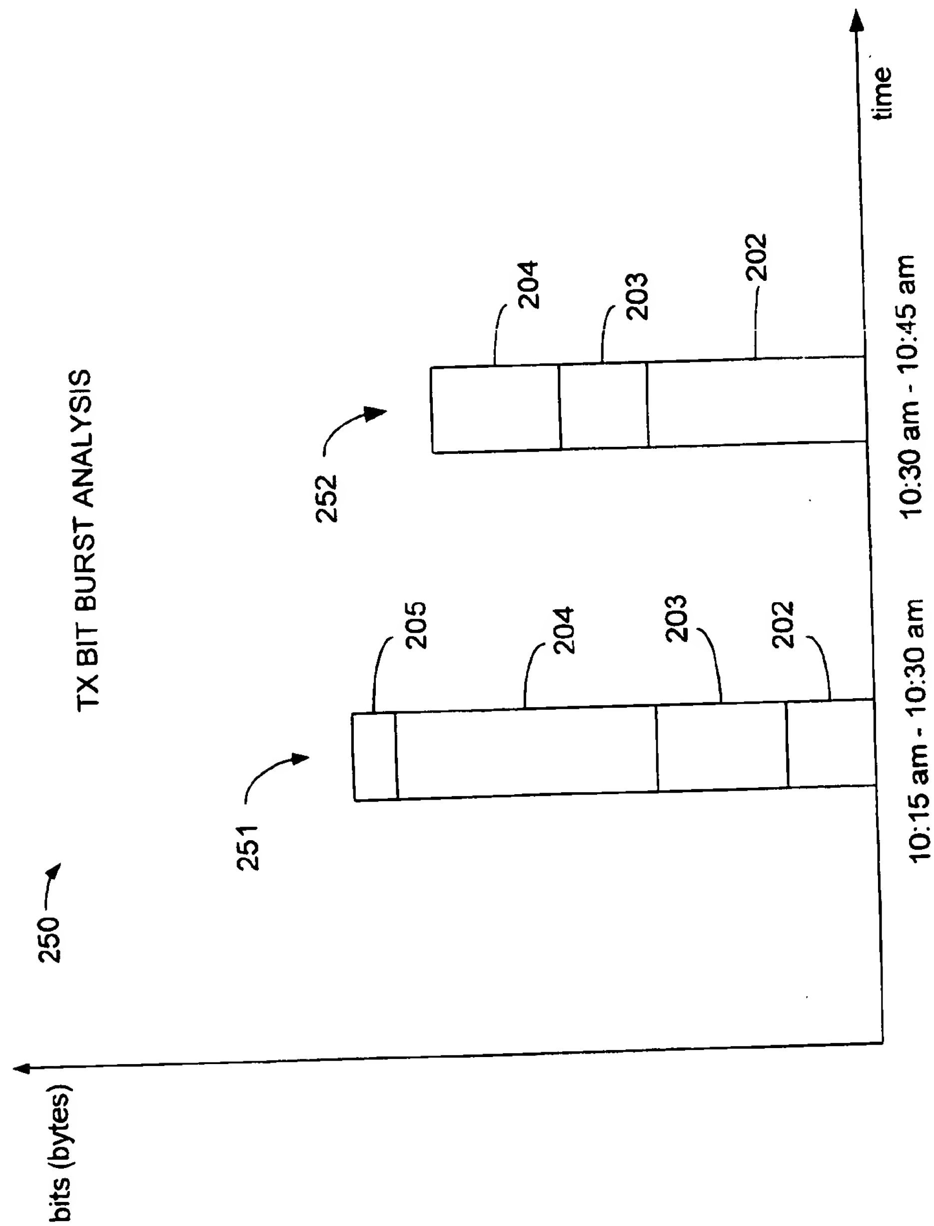

TX BIT BURST ANALYSIS
250
251
252
205
204
203
202
bits (bytes)
time
10:15 am - 10:30 am
10:30 am - 10:45 am

Fig. 5

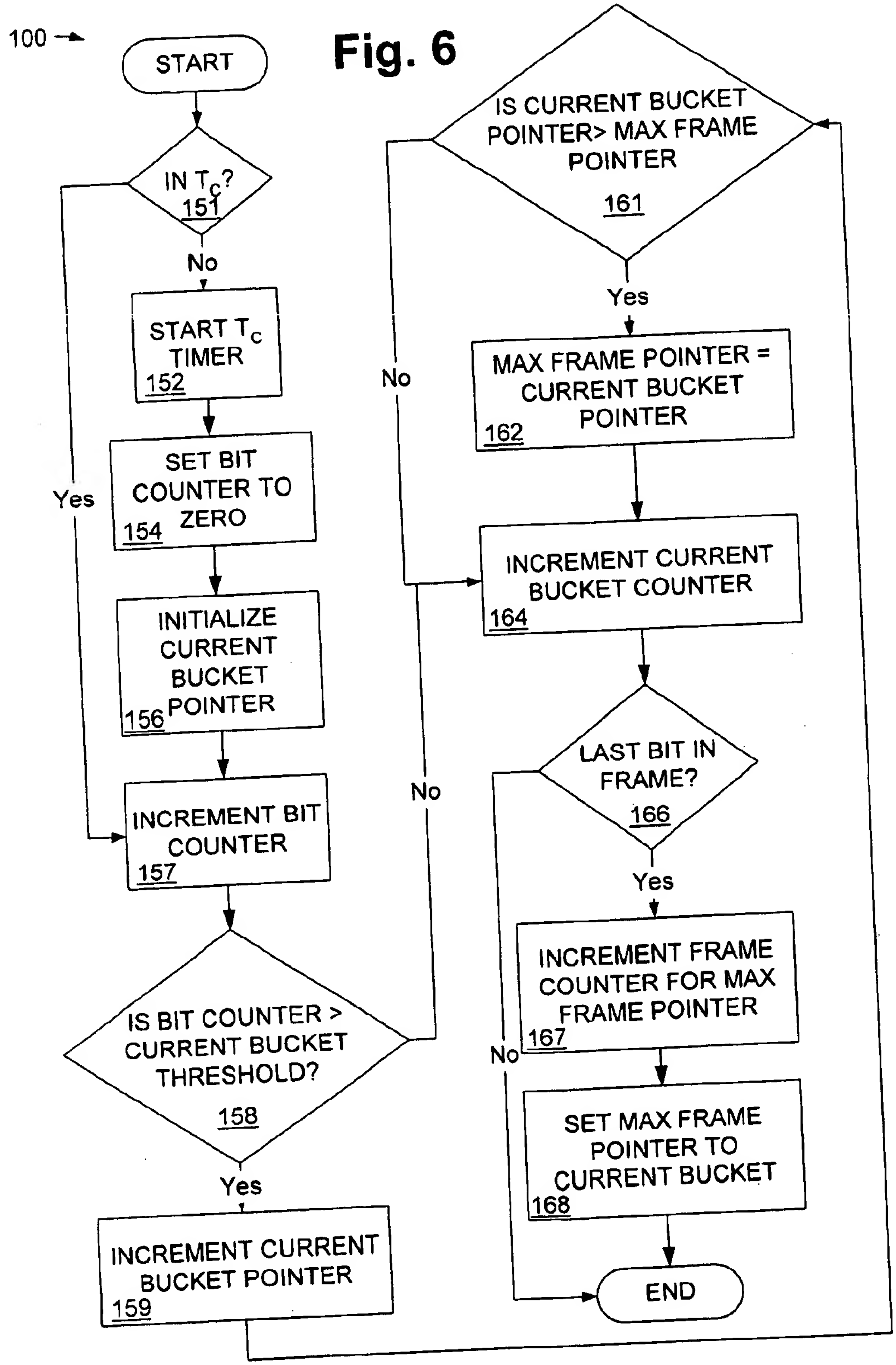

100
START
IN T_C?
151
No
START T_C TIMER
152
SET BIT COUNTER TO ZERO
154
INITIALIZE CURRENT BUCKET POINTER
156
Yes
INCREMENT BIT COUNTER
157
IS BIT COUNTER > CURRENT BUCKET THRESHOLD?
158
Yes
No
INCREMENT CURRENT BUCKET POINTER
159
IS CURRENT BUCKET POINTER> MAX FRAME POINTER
161
Yes
No
MAX FRAME POINTER = CURRENT BUCKET POINTER
162
INCREMENT CURRENT BUCKET COUNTER
164
LAST BIT IN FRAME?
166
Yes
No
INCREMENT FRAME COUNTER FOR MAX FRAME POINTER
167
SET MAX FRAME POINTER TO CURRENT BUCKET
168
END

Fig. 6

SYSTEM AND METHOD FOR CHARACTERIZING BURST INFORMATION

CROSS REFERENCE TO RELATED APPLICATION

[0001] This document claims priority to and the benefit of the filing date of copending and commonly assigned provisional application entitled METHOD FOR CHARACTERIZING BURST INFORMATION IN A FRAME RELAY NETWORK, assigned Ser. No. 60/071,756, filed Jan. 16, 1998, and hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to data communications, and, more particularly, to a system and method for characterizing burst traffic information in a communication system.

[0004] 2. Related Art

[0005] Historically, in the field of data communications, a modem, a data service unit (DSU), or a channel service unit (CSU) has used to convey information from one location to another. Digital technology now enables modems or other communication devices, such as frame relay data service units (DSU's), frame relay access units (FRAU's), and asynchronous transfer mode (ATM) communication devices to communicate large amounts of data. This communication scheme generally adheres to a model, known as the Open Systems Interconnect (OSI) Seven-Layer model. This model specifies the parameters and conditions under which information is formatted and transferred over a given communications network. A general background of the OSI seven-layer model follows.

[0006] In 1978, a framework of international standards for computer network architecture known as "OSI" (Open Systems Interconnect) was developed. The OSI reference model of network architecture consists of seven layers. From the lowest to the highest, the layers are: (1) the physical layer; (2) the datalink layer; (3) the network layer; (4) the transport layer; (5) the session layer; (6) the presentation layer; and (7) the application layer. Each layer uses the layer below it to provide a service to the layer above it. The lower layers are implemented by lower level protocols which define the electrical and physical standards, perform the byte ordering of the data, and govern the transmission, and error detection and correction of the bit stream. The higher layers are implemented by higher level protocols which deal with, inter alia, data formatting, terminal-to-computer dialogue, character sets, and sequencing of messages.

[0007] Layer 1, the physical layer, controls the direct host-to-host communication between the hardware of the end users' data terminal equipment (e.g., a modem connected to a PC).

[0008] Layer 2, the datalink layer, generally fragments the data to prepare it to be sent on the physical layer, receives acknowledgment frames, performs error checking, and re-transmits frames which have been incorrectly received.

[0009] Layer 3, the network layer, generally controls the routing of packets of data from the sender to the receiver via the datalink layer, and it is used by the transport layer. An example of the network layer is the Internet Protocol (IP), which is the network layer for the TCP/IP protocol widely used on Ethernet networks. In contrast to the OSI seven-layer architecture, TCP/IP (Transmission Control Protocol over Internet Protocol) is a five-layer architecture which generally consists of the network layer and the transport layer protocols.

[0010] Layer 4, the transport layer, determines how the network layer should be used to provide a point-to-point, virtual, error-free connection so that the end point devices send and receive uncorrupted messages in the correct order. This layer establishes and dissolves connections between hosts. It is used by the session layer. TCP is an example of the transport layer.

[0011] Layer 5, the session layer, uses the transport layer and is used by the presentation layer. The session layer establishes a connection between processes on different hosts. It handles the creation of sessions between hosts as well as security issues.

[0012] Layer 6, the presentation layer, attempts to minimize the noticeability of differences between hosts and performs functions such as text compression, and format and code conversion.

[0013] Layer 7, the application layer, is used by the presentation layer to provide the user with a localized representation of data which is independent of the format used on the network. The application layer is concerned with the user's view of the network and generally deals with resource allocation, network transparency and problem partitioning.

[0014] The communications networks that operate within the OSI seven-layer model include a number of paths or links that are interconnected to route voice, video, and/or digital data (hereinafter, collectively referred to as "data") traffic from one location of the network to another. At each location, an interconnect node couples a plurality of source nodes and destination nodes to the network. In some cases, the sources and destinations are incorporated in a private line network that may include a series of offices connected together by leased-lines with switching facilities and transmission equipment owned and operated by the carrier or service provider and leased to the user. This type of network is conventionally referred to as a circuit-switching network. Accordingly, a source node of one office at one location of the network may transmit data to a destination node of a second office located at another location of the network through their respective switching facilities.

[0015] At any given location, a large number of source nodes may desire to communicate through their respective switching facilities, or interconnect node, to destination nodes at various other locations of the network The data traffic from the various source nodes is first multiplexed through the source switching facility, and then demultiplexed at the destination switching facility and finally delivered to the proper destination node. A variety of techniques for efficiently multiplexing data from multiple source nodes onto a single circuit of the network are presently employed in private line networks. For instance, time division multiplexing (TDM) affords each source node full access to the allotted bandwidth of the circuit for a small amount of time. The circuit is divided into defined time segments, with each

segment corresponding to a specific source node, to provide for the transfer of data from those source nodes, when called upon, through the network.

[0016] Other data communications systems, in contrast, have not been as successful with employing multiplexing techniques to further enhance network efficiency. In particular, frame-relay networks offer fewer alternatives than their circuit-switching network counterparts. Frame-relay networks are one implementation of a packet-switching network. A packet-switching network, as opposed to circuit-switching network, allows multiple users to share data network facilities and bandwidth, rather than providing a specific amount of dedicated bandwidth to each user, as in TDM. Instead, packet switches divide bandwidth into connectionless, virtual circuits. Virtual circuits can be permanent virtual circuits (PVC's) or switched virtual circuits (SVC's). As is known, virtual circuit bandwidth is consumed only when data is actually transmitted. Otherwise, the bandwidth is not used. In this way, packet-switching networks essentially mirror the operation of a statistical multiplexer (whereby multiple logical users share a single network access circuit). Frame relay generally operates within layer 2 (the data link layer) of the OSI model, and is an improvement over previous packet switching techniques, such as X.25, in that frame relay requires significantly less overhead.

[0017] In all communication networks, network performance measurements are vital to the proper operation of any given network. For example, the quality of service committed to and provided by a network provider is based upon network conditions and also on conditions for which the network user is responsible. Typically, network providers will provision services to an end user by specifying a committed information rate (CIR). The CIR is the data communication rate that the provider guarantees the user. The CIR is typically some fraction of the total available line rate of the particular service being provisioned. For example, in a frame relay network, the line rate may be 1536000 bits/second (T1 rate including 24 64-kilobit (KB) channels for a total of 1.544 megabits/second (MB/s) including 8 KB signaling), while the CIR may be 48000 bytes/second (384000 bits/second (b/s)). That is, for this example, the network provider may guarantee a communication rate of 384000 b/s, while the total available line rate may be 1536000 b/s.

[0018] Some of the above described communication environments are used to transmit "bursty" data traffic. Burstiness in this context can best be described as data communication traffic that is sporadic in nature, with bursts of traffic occurring at frequent, but irregular, time intervals. When transmitting this bursty traffic, information on the size and extent of traffic bursts above the CIR is extremely useful in order to determine whether and how often a user exceeds the CIR and the extent of the burstiness of the traffic.

[0019] Typically, burst parameters are measured over 1 second time intervals, which will be denoted by T_C. The T_C interval is of fixed duration, but does not necessarily occur at fixed intervals. The receipt of data triggers a timer to begin timing the T_c interval. In order to collect burst characteristic information, existing techniques keep burst data in 1 second interval categories, or buckets. If burst categories are used based upon seconds (i.e., % of seconds that a burst was recorded at 200% CIR, for example) the resolution would be insufficient to discriminate between burst categories. This is so because the concept of "bursty seconds" does not exist in packet switching. In packet switching bursts are measured in bits (or bytes) and entire frames are marked discard eligible (DE) or discarded depending upon where the bits within the frame fall in relation to the CIR. In one second, the entire spectrum of burst categories could be encompassed. Merely choosing a single category per second would cause the bursting to appear to be worse (if worst category were chosen) or best (if lowest burst category were chosen). This manner of categorizing burst traffic is highly inaccurate.

[0020] Another problem with current systems for categorizing burst data traffic is that they require a large amount of system resource in the form of system memory. Furthermore, current systems require that excessive amounts of information be transmitted to a network management system (NMS) resulting in instances where the NMS cannot process the information received before receiving another updated set of information. This is caused by some systems that provide only one (1) second category buckets having the number of bits sent for each second supplied to the NMS for burst analysis. This small interval causes excessive data to be generated, which in turn must be sent to the NMS and analyzed. This results in the NMS being unable to keep pace with the data collection.

[0021] Therefore, it would be desirable to provide a system and method that will characterize burst information based upon usage criteria that can be completely categorized over a given time interval and without overwhelming the ability of the NMS to process and present the information to a user.

SUMMARY OF THE INVENTION

[0022] The present invention provides an improvement to a communication environment by enabling the collection and categorization of burst data traffic in a communication network and providing the information in a manner that enables the data to be economically analyzed.

[0023] This task is accomplished by providing a system for characterizing burst communication traffic. The invention includes a detector for detecting the occurrence of burst information, characterizing logic for characterizing the burst information into at least one category, and a counter for counting each occurrence of the burst information in each category.

[0024] The present invention can also be conceptualized as providing a method for characterizing burst information communication traffic, comprising the following steps. First, the occurrence of burst information is detected. Next, the burst information is characterized as belonging in at least one category. Then, each occurrence of the burst information in each category is counted with the counter being incremented for each category of detected bursts of data.

[0025] The invention has numerous advantages, a few of which are delineated hereafter, as merely examples.

[0026] An advantage of the present invention is that it enables the capture and categorization of burst data information over a time period sufficient to allow useful analysis.

[0027] Another advantage of the present invention is that it allows burst data information to be collected and catego-

rized in a manner that optimizes the resources available to a network management system (NMS).

[0028] Another advantage of the invention is that because bits and frames are categorized, it allow precise correlation with frame relay switch information and comparison with data delivery success rate, which is presented in bits or frames.

[0029] Another advantage of the invention is that it reduces the amount of memory required in the communication device.

[0030] Another advantage of the invention is that it reduces the amount of polling required by a network management system.

[0031] Another advantage of the invention is that it improves the performance of a network management system by allowing the processing to occur in a communications device.

[0032] Another advantage of the present invention is that it is simple in design, reliable in operation, and its design lends itself to economical mass production in communication devices.

[0033] Other features and advantages of the present invention will become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional features and advantages be included herein within the scope of the present invention, as defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] The present invention, as defined in the claims, can be better understood with reference to the following drawings. The components within the drawings are not necessarily to scale relative to each other, emphasis instead being placed on clearly illustrating the principles of the present invention.

[0035] FIG. 1 is a block diagram of a network model illustrating the framework within which the present invention operates;

[0036] **FIG. 2** is a schematic view illustrating a communication device in which the burst categorization logic resides;

[0037] **FIG. 3** is a schematic view illustrating the network access module of **FIG. 2** including the burst categorization logic of the present invention;

[0038] **FIG. 4** is a graphical representation illustrating the operation of the burst categorization logic of **FIGS. 2 and 3**;

[0039] **FIG. 5** is a graphical representation of the information supplied by the burst categorization logic of **FIGS. 2 and 3**; and

[0040] **FIG. 6** is a flow chart illustrating the architecture, functionality, and operation of the burst categorization logic of **FIGS. 2 and 3**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0041] The burst categorization logic of the present invention can be implemented in software, hardware, or a combination thereof. In the preferred embodiment, the burst categorization logic is implemented in software that is stored in a memory and that is executed by a suitable microprocessor (uP) situated in a communications device. However, the burst categorization program, which comprises an ordered listing of executable instructions for implementing logical functions, can be embodied in any computer-readable medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions.

[0042] In the context of this document, a "computer-readable medium" can be any means that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The computer readable medium can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a nonexhaustive list) of the computer-readable medium would include the following: an electrical connection (electronic) having one or more wires, a portable computer diskette (magnetic), a random access memory (RAM) (magnetic), a read-only memory (ROM) (magnetic), an erasable programmable read-only memory (EPROM or Flash memory) (magnetic), an optical fiber (optical), and a portable compact disc read-only memory (CDROM) (optical). Note that the computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via for instance optical scanning of the paper or other medium, then compiled, interpreted or otherwise processed in a suitable manner if necessary, and then stored in a computer memory.

[0043] Furthermore, the preferred embodiment of the burst categorization logic is illustrated in the context of a frame relay communications network; however, the concepts and principles of the burst categorization logic are equally applicable to other communication techniques in which the data communicated may be considered "bursty" in nature.

[0044] **FIG. 1** shows a communication topography **11** in which communications devices containing the burst categorization logic operate. In general the communications environment includes a plurality of user devices **4***a*, **4***b*, and **4***c*, each connected to a plurality of communication devices **12***a* **12***b*, and **12***c* over connections **6***a*, **6***b*, and **6***c* respectively. Communication devices **12***a*, **12***b*, and **12***c* can be any communication device such as a modem, or a frame relay access unit (FRAU) that communicates bursty data traffic over communication network **16** in a conventional manner. Data that is nonperiodic, or transmitted at irregular intervals, is considered bursty in nature. Typically, bursty data is transmitted in packetized form by a packet-switching network, which lends itself to the transmission of bursty data. Communication network **16** includes components that are known in the art and illustratively connect to communication devices **12***a*, **12***b*, and **12***c* over connections **21**, **22**, and **23** respectively. Connections **21**, **22**, and **23** are physical links and can be, for example, T1/E1 service or any analog or digital data service (DDS).

[0045] Communication network **16** can be a frame relay communication network and is typically characterized by a mesh network of links (not shown) interconnecting a matrix of intermediate nodes (not shown) through frame relay switches **17** and **18**. For simplicity only two frame relay switches are illustrated herein. However, communication network **16** will typically contain many switching devices. The links are identified by data link connection identifiers (DLCI's), which are used to identify the logical connection over which the subject data is transported. The use of DLCI's allows multiple logical connections to be multiplexed over the same physical channel. For example, communication device **12***a* may communicate with communication device **12***b* over a predefined communication path or link within network **16**. This communication path will generally be defined by a number intermediate nodes. The communication link that interconnects communication device **12***a* and communication device **12***b* may be completely separate and distinct from that which interconnects communication device **12***a* and **12***c*. Alternatively, a segment of the two above-described communication links may be shared. Whether the links are separate or shared is a function of a number of factors and generally is determined by the service provider.

[0046] Within network **16** the communication path between communication device **12***a* and communication device **12***b*, for example, will be the same in both directions. That is, data transmitted from communication device **12***a* to communication device **12***b* will traverse the same path (i.e., interconnecting, intermediate nodes) as will data transmitted from communication device **12***b* to communication device **12***a*. This path of intermediate nodes is defined by DLCI's, and is commonly referred to as a permanent virtual circuit (PVC). This name derives from the fact that the circuit is permanent in that it does not change from transmission to transmission. It is, however, virtual in the sense that a unitary physical connection (such as a dedicated leased line) is not established and maintained between the two end points. If for some reason or another the service provider decides to change the interconnecting path (i.e., reconfigure or redefine the intermediate nodes), the service provider will communicate this changed communication path to the users and a new set of DLCI's will be used in order to properly route the data from end point to end point. DLCI's are assigned to and define all the points in a network through which data passes. For simplicity the burst categorization logic **100** is described herein as applied to permanent virtual circuits (PVC's); however, the burst categorization logic **100** is equally applicable to communication networks employing switched virtual circuits (SVC's). PVC's **19***a*, **19***b*, and **19***c* of **FIG. 1** illustrate the concept of multiple communication paths within network **16**. Bursty data traversing network **16** is typically monitored by the FRAU's **12***a*, **12***b*, and **12***c* and by frame relay switches **17** and **18** in order to determine the characteristics and the flow of data traversing the network and is typically measured in bits (or bytes). Data is typically characterized by the size and extent of bursts occurring above a committed information rate (CIR). A CIR is the data rate at which a service provider is meeting a promised data rate commitment to an end user. The CIR is typically below the possible "line rate", which is the maximum rate at which the particular communication channel may operate. However, in the case of bursty communication data, the CIR of a particular communication channel is frequently exceeded. The burst categorization logic of the present invention creates "buckets", or categories into which bursts (of bits, or bytes) of data are categorized for analysis and display by network management system (NMS) **13** and will be explained in detail hereafter.

[0047] **FIG. 2** shows a block diagram of a communication device **12** in which the burst categorization logic **100** of the present invention resides. The logic of the present invention resides within each communication device **12**. Communication device **12** is typically the access unit that connects user equipment to a communication network and is illustratively a frame relay access unit (FRAU).

[0048] Communication device **12** contains a number of conventional components that are well known in the art of data communications. Network access module (NAM) **31** includes microprocessor (uP) **32**, which is configured to control the operation of the communication device's transmitter **33** and receiver **34** and which is configured to couple to memory **37** over bus **38**. Access to communication channel **21** is provided by NAM **31**. Omitted from **FIG. 2** for simplicity are a number of conventional components of communication device **12** that are not necessary to explain the operation of the burst categorization logic and known to those skilled in the art.

[0049] Communication channel **21** is typically the physical wire that extends from a communication network and connects to NAM **31** to provide access into a communication network. However, communication channel **21** can be any medium for connecting the communication device **12** to a communication network.

[0050] Contained within memory **37** is the burst categorization logic **100** of the present invention. Burst categorization logic **100** is configured to enable and drive uP **32** to allow the detection and categorization of burst data transmitted by communication device **12** over network **16**. Because burst categorization logic **100** is an algorithm that configures and drives uP **32**, it is depicted as residing within both memory **37** and uP **32**. Burst categorization logic **100** detects and categorizes burst data transmissions and causes bit counter **115** (**FIG. 3**) to increment each time a burst is detected in each category and will be described in detail hereafter. Similarly, frame relay switch **67** resides in memory **37** and executes in uP **32**.

[0051] Turning now to **FIG. 3**, shown is the network access module (NAM) of **FIG. 2** including the burst categorization logic **100** of the present invention.

[0052] Network access module (NAM) **31** illustratively includes communication port **62** (port 1), communication port **64** (port 2), and network port **66**. NAM **31** may contain fewer or additional ports and ports **62**, **64** and the network port **66** are shown for illustrative purposes only. Ports **62**, **64**, and the network port **66** each connect to frame relay switch **67** through connections **71***a*, **71***b*, and **71***c* respectively. Illustratively, network port **66** connects to communication channel **21** and port **62** (port 1) connects to user device **4**.

[0053] The operation of frame relay switch **67** will be discussed hereafter. Frame relay switch **67** receives configuration updates through connection **74** from controller **61**, which contains the burst categorization logic **100** of the present invention.

[0054] Controller **61** contains the burst categorization logic **100** that enables FRAU 12 to detect the presence of burst communication data on the local management interface and categorize that information using sliding window T_c based upon bits or frames detected.

[0055] Burst categorization logic **100** includes data detector **110**, which detects the presence of burst data transmission on the local management interface (LMI) over connection **68** from LMI protocol engine **105**. Once a burst is detected by data detector **110**, burst categorization logic **100** sends a message on connection **101** to burst categorization database **48** containing information pertaining to the burst message received. The burst message received is categorized depending upon the amount of data received in the measured burst and stored in burst categorization database **48**. Once the burst is categorized, the appropriate counter will be incremented for that category. For example, the appropriate bit counter **115** will be incremented for that category where burst data is detected. It should also be noted that while depicted as residing within NAM 31, the LMI protocol engine **105** is part of the frame relay area.

[0056] Also included in burst categorization logic **100** are T_C timer **125**, current bucket counter **130**, frame counter **140**, max frame pointer **135** and current bucket pointer **120**, the operation of which will be described in detail with reference to **FIG. 6**. Furthermore, while illustrated as single elements, bit counter **115**, current bucket pointer **120**, and frame counter **140** each comprise a plurality of counters, one for each category of detected burst data.

[0057] **FIG. 4** shows a graphical representation **200** illustrating the operation of the burst categorization logic **100** of **FIG. 2**. Depicted on the horizontal axis of graph **200** is time in intervals T_C, which may be separated in time if no data is sent. The beginning of a new T_C interval is synchronized to the detection of data by data detector **110** of **FIG. 3**. Shown on the vertical axis of graph **200** are the burst characterization categories, or buckets, of the present invention as a function of data rate. T_C (the committed rate measurement interval) is the time interval during which a user is allowed to send B_C (committed amount of data) or B_C (committed amount of data) plus Be (excess amount of data). T_C is computed from the service parameters of CIR and B_C, as $T_C = B_C/CIR$, where CIR is the committed information rate and B_C is the committed amount of data. T_C is not a periodic measurement interval, but rather a sliding window that is triggered by the receipt of user data. Once the T_C interval (i.e., **210**, **211**, etc. of **FIG. 4**) has been initiated, it continues until it completes its computed duration. For example, T_{C1}, **210** is initiated upon receipt of burst data represented by point **202***a*. Once T_{C1} elapses another timing interval will only begin upon receipt of another burst transmission. This concept is illustrated by blank space **215** between timing interval T_{C1} and T_{C2}. Timing interval T_{C2} is not begun until the receipt of, in this example, data represented by point **202***c*.

[0058] Line **201** illustrates the committed information rate (CIR), which is the rate that the service provider typically guarantees to an end user. The points referenced by numerals **202**, **203**, **204** and **205** illustratively indicate detected bursts of data traffic detected at 0%-100% CIR, 101%-151% CIR, 151%-200% CIR, and 201%-300% CIR respectively. As can be seen, the burst categorization logic **100** detects each burst of data and categorizes each burst according to its data rate.

[0059] To illustrate the concept of burst data categories consider the following. The region of data rate between zero (0) and the CIR can be considered one category, or bucket. The region of data rate between, for example, the CIR and 150% CIR can be considered another category, or bucket. Similarly, the region between 151% CIR and 200% CIR may be another burst category, and the region of 201% CIR to 300% CIR may yet be another category. These categories are for illustrative purposes only and may be of varying scale. For example, the categories may alternatively be classified as a percentage of line rate, or the categories may be classified based upon raw data numbers.

[0060] The burst categorization logic **100** of the present invention allows the categorization of burst data in a plurality of categories in any given time interval. For example, in time interval T_{C1} **210** (typically, one (1) second) there may be transmitted multiple bursts of data illustrated by points **202***a* and **202***b* in one category, and point **204***a* in another category. The burst data represented by points **202***a* and **202***b* were classified as being somewhat less than the CIR while the burst data represented by point **204***a* is classified as being in the range of 151% CIR to 200% CIR. The burst categorization logic **100** of the present invention discriminates and tracks bursts of data at different rate categories occurring in a given time interval. Each time a new time interval is begun (e.g., the T_{C2} interval denoted by **211**), the data rate is reset to zero and as the data rate crosses a threshold (e.g., as a % of CIR, % of line rate, or a fixed number) the number of bits (or bytes) above the threshold is again counted in the category in which it occurs

[0061] Each time that a burst occurs in a given category, bit counter **115** (**FIG. 3**) increments thus keeping a count of the number of occurrences of burst data in each category. Each time that a burst is detected, burst categorization logic **100** updates burst category database **48** over connection **101**.

[0062] In addition, the burst categorization logic **100** allows the storage intervals to be longer than the typical 15 minute storage interval, while the burst information is still captured satisfactorily, with appropriate granularity and resolution.

[0063] Furthermore, because the T_C timer is switched according to the receipt of data, better correlation with frame relay switch statistics can be achieved.

[0064] For example, the burst information is still captured, however, there is less performance impact on the network management system (NMS), which can read fewer buckets in which the bursts are already categorized.

[0065] The aforementioned bursts of data (i.e., **202**, **203**, etc.) could be identified as bits for higher resolution, or could be identified as bytes to prevent the counters from overflowing. Additionally, a frame count can be kept for each category such that the worst bit category for that frame would cause a frame count to be incremented. This may be desirable because service providers keep information based upon frame counts (as do frame relay switches). Keeping the frame counts allows the correlation of data with the switches inside a network for troubleshooting.

[0066] **FIG. 5** shows a graphical representation of the information supplied by the burst categorization logic of **FIGS. 2 and 3** as presented to a user, or a network operator. The horizontal axis of graph **250** indicates time of day and

the vertical axis of graph **250** indicates burst data in bits (or bytes). The stack bars in graph **250** illustrate one manner in which the information gathered by the burst categorization logic **100** may be presented on a graphical display device. Stack bar **251** includes bit (or byte) burst data gathered during the time intervals described in **FIG. 3**, however in **FIG. 4** the data is arranged to reflect the quantity of bursts detected in each category. For example, all the information collected that occurred below the CIR is depicted as portion **202** of stack **251**. Similarly, the portion of information collected that occurred between 101% CIR and 150% CIR is depicted as portion **203** of stack **251**, the portion of information collected that occurred between 151% CIR and 200% CIR is depicted as portion **204** of stack **251**, and the portion of information that occurred between 201% CIR to 300% CIR is depicted as portion **205** of stack **251**.

[0067] Stack **251** illustratively represents all the burst data collected during the 15 minute period between 10:15 am and 10:30 am on a particular day. Similarly, stack **252** represents all the burst data collected between 10:30 am and 10:45 am. Stack **252** illustrates the condition where no burst data was detected as occurring above 200% of the CIR as noted by the absence of a portion **205**. These times are shown for illustration purposes only. Any time period may be analyzed and presented using the concepts illustrated herein.

[0068] **FIG. 6** is a flow chart **100** illustrating the architecture, functionality, and operation of the burst categorization logic, which in the preferred embodiment is software or firmware, of **FIGS. 2 and 3**.

[0069] In decision block **151** it is determined whether a received burst of information is contained within the timer period of a currently operating T_C timer. If T_C timer **125** is currently timing, then the received information causes bit counter **115** to increment. If the burst data is received while T_C timer **125** is currently idle, then in block **152** T_C timer **125** is started.

[0070] In block **154** bit counter **115** is set to zero, and in block **156** current bucket pointer **120** is initialized. In block **157** bit counter **115** is incremented.

[0071] In decision block **158** it is determined whether the value of bit counter **115** is greater than the value of the current bucket threshold. If the current bucket threshold exceeds the value of the bit counter **115**, then current bucket counter **130** is incremented. If the value of the bit counter **115** exceeds the current bucket threshold, then in block **159** the current bucket pointer **120** is incremented.

[0072] In decision block **161** it is determined whether the value of the current bucket pointer **120** exceeds the value of the max frame pointer **135**. If the current bucket pointer exceeds the max frame pointer, then in block **162** the max frame pointer 135 equals the current bucket pointer **120**. If the value of the current bucket pointer **120** does not exceed the value of the max frame pointer **135**, then in block **164** the current bucket counter **130** is incremented.

[0073] In decision block **166** it is determined whether the bit is the last bit in the frame. If the current bit was the last bit in the frame, then in block **167** frame counter **140** is incremented for the max frame pointer **135**. Finally, in block **168**, the max frame pointer **135** is set to the current bucket. If the bit was not the last bit in the frame, then the process is ended.

[0074] It will be obvious to those skilled in the art that many modifications and variations may be made to the preferred embodiments of the present invention, as set forth above, without departing substantially from the principles of the present invention. For example, the system and method for characterizing burst information can be implemented in any communication environment in which bursty data traffic is communicated. All such modifications and variations are intended to be included herein within the scope of the present invention, as defined in the claims that follow.

Therefore, the following is claimed:

1. A system for characterizing burst communication traffic, comprising:

detecting means for detecting the occurrence of burst information;

characterizing means for characterizing said burst information into at least one category; and

counting means for counting each occurrence of said burst information in each said category.

2. The system of claim 1, wherein each occurrence of said burst information is categorized by bits.

3. The system of claim 1, wherein each occurrence of said burst information is categorized by frames.

4. The system of claim 1, wherein said burst information is frame relay data.

5. The system of claim 1, wherein said burst information is asynchronous transfer mode (ATM) data.

6. The system of claim 1, wherein said characterizing means further includes:

means for detecting a quantity of said burst information; and

creating at least one category into which said burst information is placed.

7. The system of claim 1, wherein said at least one category represents a portion of a committed information rate (CIR).

8. A method for characterizing burst information communication traffic, comprising the steps of:

detecting the occurrence of burst information;

characterizing said burst information into at least one category; and

counting each occurrence of said burst information in each said category.

9. The method of claim 8, wherein said burst information is categorized by bits.

10. The method of claim 8, wherein said burst information is categorized by frames.

11. The method of claim 8, wherein said burst information is frame relay data.

12. The method of claim 8, wherein said burst information is asynchronous transfer mode (ATM) data.

13. The method of claim 8, wherein said characterizing step further includes the steps of:

detecting a quantity of said burst information; and

creating at least one category into which said burst information is placed.

14. The method of claim 8, wherein said at least one category represents a portion of a committed information rate (CIR).

15. A computer readable medium having a program for characterizing burst information communication traffic, the medium comprising:

means for detecting the occurrence of burst information;

means for characterizing said burst information into at least one category;

means for counting each occurrence of said burst information in each said category.

16. The medium of claim 15, wherein said burst information is categorized by bits.

17. The medium of claim 15, wherein said burst information is categorized by frames.

18. The medium of claim 15, wherein said burst information is frame relay data.

19. The medium of claim 15, wherein said burst information is asynchronous transfer mode (ATM) data.

20. The medium of claim 15, wherein said characterizing means further includes:

means for detecting a quantity of said burst information; and

means for creating at least one category into which said burst information is placed.

21. The medium of claim 15, wherein said at least one category represents a portion of a committed information rate (CIR).

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